Impact of Import and Export of Energy Supply on the Total Electricity Generation Model

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Abstract - Renewable and non-renewable sources are crucial especially in the production of electricity. In Malaysia, we are mainly using fossil fuels to generate electricity. To ensure a sufficient amount of energy sources, we require to import these energy supplies. Since Malaysia has a large amount of petroleum and crude oil, we need to export the resources and indirectly, it can contribute by increasing our country's income. Thus, the main purpose of this study is to explore any significant impact of import and export of energy on the total electricity generation in Malaysia. All of the data are taken from the Energy Commission (Malaysia). Range from 1980 until 2017 every year. Ordinary least square (OLS) and correlation analysis have been implemented to achieve the objectives of our study. The energy supply was found to be significant with the total electricity generation exclude the export of crude oil which shows it is insignificant. Then, our findings proved that the highest correlation is between the import of petroleum and import of coal. On the contrary, the import of crude oil is the lowest negatively correlated to the export of crude oil. For the K-S test, it justified that the residuals are normally distributed. Our results confirm the energy supply influences either in a positive or negative impact on the total production of electricity in Malaysia.

Keywords - Electricity Generation, Energy Supply, Import, Export.

I. INTRODUCTION

Electricity is one of the fundamental needs of our daily life. The electricity is progressively the “fuel of choice” to the economy especially for the countries that rely heavily on the light industrial sectors, services as well as digital technologies. The fuel of choice means the electricity is increasingly essential for well-being daily life which exponentially increases the electricity demand. This is mainly due to the development of global industrialization starting in the middle of the 18th century. As reported by the International Energy Agency [1], the final production of electricity worldwide is approximately 20% and is expected to increase in the future to fulfil the high electricity demand. Undeniably, the increasing electricity production will certainly pressure the earth’s finite resources and ecosystem. Thus, human needs and maintaining the natural system should run in parallel. In other words, the energy should be generated at lower environmental costs to effectively fulfil the high energy demand.

To the best of our knowledge, many countries around the world are highly depending on the fossil fuels to produce electricity, where 85% of the global energy consumption relies on the fossil fuels [1]. Over-consumption of fossil fuels may induce many bad impacts on the world. Excessive burning of fossil fuels may cause a high percentage of greenhouse gases (GHG) emissions such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These gases may increase the percentage of absorption of outgoing radiation which will significantly increase the global temperature. Based on the Intergovernmental [3] report, the average temperature of the earth is approximately 15^{o}C and it could increase by 2-4^{o}C or more during this century if the utilization of fossil fuels keeps increasing.

High utilization of fossil fuels also may threaten the resources. The high electricity demand has forced the energy producers to extract the finite reserves of fossil fuels at an excessively high rate which leads to fast depletion of resources. The fossil fuels are exhaustible, and the reserves are decreasing over time. As been reported [4], it is approximated that the reserves of oil and natural gas can only supply for another 40 years, and coal can be used for another 100 years if they are consumed at today’s rates. Due to these deficiencies of fossil fuels, people around the world are encouraged to transform their conventional energy sources to safer, cleaner, and naturally replenished renewable energy.

The utilization of renewable energy in producing electricity may provide a huge benefit especially to the development of social and economic, energy supply, as well as environmental and health. However, its deployment also may induce several critical challenges. The first factor is the distributed nature of renewable resources where some of the potential renewable resources are isolated and located away from the demand centres. In Europe, for instance, solar and wind energy are much generated in southern and northern Europe, but the demand is primarily in its central continent. This is certainly leading to a mismatch in energy demand and supply. To avoid the issue of energy surplus and to fulfil the energy demand, a high transmission cost is required to transmit the energy produced to the energy needed places.

The second factor is the environment and social impacts. For instance, the installation of wind turbines requires a huge land which may lead to environmental degradation, noise pollution, and bat's and bird's fatalities as well as degradation of wildlife habitats. Apart from these, another great challenge is non-storable and intermittent behaviour of some renewable energy resources. To cope with the intermittency problem, the energy producers are required to build more effective tools or strategy such as creating batteries which can store a large amount of energy generated. Indeed, that is one of the main challenges in the renewable energy world where the energy produced cannot be stored and has to be used immediately. If many effective batteries can be built up, the energy produced can be stored and utilized whenever the renewable energy source is unavailable (for example, solar energy cannot be generated during night hours).

Despite the utilization of fossil fuels may induce many bad consequences to the environment, fossil fuels are still crucial to the electricity system as a backup plan of intermittent renewable energy production. As for a rapidly developing country in Southeast Asia, Malaysia, its economic growth is highly dependent on its abundant energy resources, mainly natural gas and crude oil. Over the past 30 years, Malaysia has been using oil, natural gas and coal in its energy generation and involved in the international business of export and import of these energy supplies. Knowingly, Malaysia is the major oil exporter among ASEAN countries. However, it is becoming a net importer of oil due to the significant rise of oil consumption and the decline in oil production within the country [6]. As for natural gas, Malaysia is ranked as the world's fourth-largest exporter of liquified Natural Gas (LNG) as reported in The Star [7]. On the other hand, Malaysia has been the major importer of coals which primarily obtained from Indonesia and Australia [8]. Furthermore, based on the statistics reported by Energy Commission [9], as of 2016, Malaysian export and import of oil are approximately 60.5% and 39.5%, respectively. Meanwhile, LNG has been exported by about 78.2% and imported by 3.6%. As mentioned previously, Malaysia is the major importer of coals where its total import is almost 100%.

There are voluminous previous studies investigated the various issue of energy such as energy security [10] and the relationship between energy and macroeconomic factors [2],[11], [12] [13] [14], however, there are very limited resources of literature emphasizing on the impact of export and import of fossil fuels supply on electricity generation. Since Malaysia is blessed with a lot of energy resources such as oil, gas and coal, they could be used to supply energy and power the economy of a nation. Furthermore, they can be exported which may increase the GDP of the country. Nevertheless, these resources are depletable and may insufficiently fulfil high energy demand. If this happens, the export of resources should behold and may require some import of energy supply. The upward and downward trend of export and import of fossil fuels may significantly affect the total electricity production. Thus, in this study, we are highly motivated to investigate this trending issue towards Malaysian electricity production. The annual data is taken from Malaysia Energy Information Hub (MEIH) range from 1980 to 2017 for empirical analysis.

The structure of this paper is structured as follows: Section 2 explains the methodology used in the study. Section 3 explains the empirical results and limitation. And the final section of the paper provides the overall conclusion and suggests some implication for future research.

II. METHODOLOGY

Augmented Dickey-Fuller Test (ADF)

Before doing the empirical analysis, we perform the Augmented Dickey-Fuller Test (ADF)to check the stationarity of the data. If the ADF test rejects the null hypothesis, it means the series is stationary in its mean and variance and does not has unit root:

H_0 : The series is not stationary and has a unit root.

H_1 : The series is stationary and has no unit root.

To carried out the ADF test, we used EViews software. The ADF test function is given as [7]:

$$\Delta y_t = \alpha + \gamma t + \beta y_{t-1} \sum_{i=1}^{n} \delta_i \Delta y_{t-1} + \varepsilon_t \qquad (1)$$

where

t = time index,

α = intercept constant called a drift,

γ = coefficient on a time trend,

β = coefficient presenting process root,
n = lag order of the first- differences autoregressive process,
ε_t = independent and identically distributed residual term.

Multiple Linear Regression

After checking the stationarity of the data, we examine the relationship between independent and dependent variables using Ordinary Least Squares (OLS). OLS is a technique for estimating the unknown parameters in a linear regression model. It has been applied in the voluminous study due to its effectiveness and efficiency in estimating the statistical relationship and impact of one independent variable on the dependent variable. There are a few classical linear regressions (CLRM) assumptions that must be followed. The assumptions consist of the constant variance assumption, the assumption of correct functional form, the normality assumption, and the independence assumption. If these assumptions hold, the OLS procedure creates the best possible estimates. In our study, we use logarithmic transformation to have nicer data. So, we propose a model as follows:

$$\ln y_t = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \varepsilon_t \quad (2)$$

where,

$\ln y_t$ = log of total electricity generation,
$\ln x_1$ = log of export of crude oil,
$\ln x_2$ = log of export of petroleum,
$\ln x_3$ = log of import of coal,
$\ln x_4$ = log of import of crude oil,
$\ln x_5$ = log of import of petroleum,
β_0 = intercept,
$\beta_1, \beta_2, \beta_3, \ldots, \beta_5$= estimated oefficient of independent variables,
ε_t = 0.

Test of Significance

Next, we test the significance of the independent variables in the model using t-test or also known as a significance partial test. Mathematically, the t-test is stated as [1]:

$$t = \frac{\bar{x}-\mu_0}{s/\sqrt{n}}, \sim t_{(n-1)} \text{ where } s = \frac{\sum(x-\bar{x})^2}{n-1} \quad (3)$$

where

$\bar{x}$ = sample mean
μ = population mean,
n = sample size,
s = sample standard deviation.

If p-value< significance level, then we reject the null hypothesis, H_0, where our H_0 is the independent variable not statistically significant to the total electricity generation. We set the significance level, α, to be 0.05.

F-Test

While t-test is to test the partial significance, the F-test is often used to test the overall significance of the model. In other words, F-test is a statistical test to find the best linear model which gives a better fit of the population, by assessing multiple coefficients simultaneously. The hypothesis is as follows:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$
H_1: at least one of β_1, β_2, β_3, β_4 and β_5 does not equal to 0.

If the F-statistics (model) less than $F_{[0.05]}$, it fails to reject the null hypothesis and vice versa. The F-test is stated as below [1]:

$$F = \frac{(SSR_r - SSR_{ur})/q}{SSR_{ur}/[n-(k+1)]} \sim F_{q,n-(k+1)} \quad (4)$$

where,

SSR_r = sum of squared residuals (restricted),
SSR_{ur} = sum of squared residuals (unrestricted),
q = number of restrictions,
n = number of observations,
k = parameters in the unrestricted model.

Pearson Correlation
To examine the strength of the linear relationship between variables, we use the Pearson Correlation, where its values ranging from -1 to +1. The formula for correlation is as stated below [4]:

$$C_{ij} = Corr[X_i, X_j] = \frac{Cov[X_i, X_j]}{\sigma_i \sigma_j} \quad (5)$$

$$\text{where } Corr[X_i, X_j] = (n(\sum ij) - (\sum i)(\sum j)) \quad (6)$$

where,

n = number of observations,
$\sum ij$ = total of i and j,
$\sum i$ = total of i,
$\sum j$ = total of j,
σ_i = standard deviation of i,
σ_j = standard deviation of j.

III. RESULTS

Brief Description
Fig 1 illustrates the plot of total electricity generation in Malaysia based on import and export of energy supply. Based on the plot, we can see that there is an increasing trend against years from years 1980 until 2017. This is highly due to an increase in several populations which leads to a massive increase in the electricity demand.

More specifically, **Fig 1** shows the trend between the total electricity generation and import and export of energy supply. The variables export of crude oil (x_1)and import of coal(x_3) seems to rise against years in the total production of electricity. While a decreasing trend from 1980 to 1984 in the export of petroleum(x_2) and it starts to increase along with the total electricity generated until 2017. Next, x_4 which is the import of crude oil starts to increase in early 1980 otherwise decrease in the production of electricity. Then, in 2000, both export of petroleum(x_2)and import of crude oil(x_4) rise until 2017. Lastly, import of petroleum (x_5)is increasing year by year until in 2000, both plots rise in the same value. In conclusion, all of the variables illustrate the increasing and a decreasing trend in a certain period of years against the total electricity generation in Malaysia.

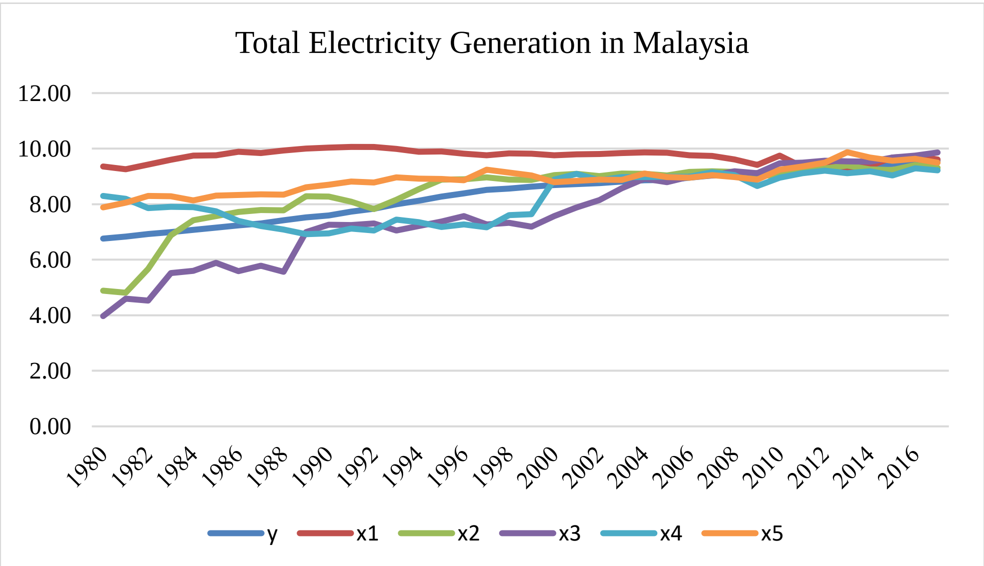

Fig 1. Total Electricity Generation and Import and Export of Energy Supply

Augmented Dickey-Fuller

Table 1 summarizes the result of all variables after doing ADF test. The ADF test is an important step before all of the variables undergo regression analysis to ensure the stationarity of the data. If the data is found not in stationarity state, we should proceed with the differencing process.

Table 1. Result for ADF Test

Variables	Level form		First Difference		Series, I(n)
	t-test	p-value	t-test	p-value	
y	0.1121	0.9963	-4.1263	0.0130	I(1)
x_1	-2.6041	0.2808	-7.5470	0.0000	I(1)
x_2	-2.6100	0.2789	-5.2492	0.0008	I(1)
x_3	-3.2668	0.0877	-7.3439	0.0000	I(1)
x_4	-2.3548	0.3958	-5.6232	0.0003	I(1)
x_5	-2.8015	0.2058	-6.3377	0.0000	I(1)

For the ADF test, the null hypothesis, H_0 is the series is not stationary and has unit root whereas, for the alternative hypothesis, H_1 is the series is stationary and has no unit root. Based on **Table 1** above, all the variables in the model fail to reject the null hypothesis at the level form since their p-values are larger than 0.05 at the 0.05 significance level. Thus, we can conclude that they are not stationary and have a unit root at the level form. To transform into the stationary state, we find the first difference and the result shows that the p-values are smaller than 0.05 at 0.05 level of significance. It means that the variables in the model are stationary and do not have a unit root at the first difference, I (1). Thus, we have a piece of strong evidence to reject the null hypothesis.

Multiple Linear Regression

Table 2. RStudio Output of a Regression Analysis

Variables	Estimated Coefficients	t	Prob
β_0	0.99908	0.35042	0.7283
x_1	-0.25977	-1.25600	0.2168
x_2	0.24412	3.67964	0.0009
x_3	0.14185	2.16950	0.0376
x_4	0.22373	3.43851	0.0016
x_5	0.55106	3.57354	0.0011
Multiple R-squared: 0.9702 Adjusted R-squared: 0.9655 F-statistic: 208.3 on 5 and 32 DF p-value: < 2.26e-16			

Estimated Parameters

In estimated parameters, it employs more than one regressor to explain the regress and in the model. In our case, $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5$ are the mean values of the dependent variable, y_t, when the values of independent variables of the export of crude oil are x_1, the export of petroleum is x_2, import of coal is x_3, import of crude oil is x_4 and import of petroleum is x_5. Apart from that, β_0, β_1, β_2, β_3, β_4 and β_5 are the regression parameters relating the mean value of y_t to x_1, x_2, x_3, x_4 and x_5. Also, ε_t is an error term where we assume ε_t to be 0.

Table 2 shows the output of R Studio Based on the regression analysis; we obtain:

$$\ln y = 0.99908 - 0.25977 \ln x_1 + 0.24412 \ln x_2 + 0.14185 \ln x_3 + 0.22373 \ln x_4 + 0.55106 \ln x_5$$

The point estimate β_1= -0.25977. It means we estimate that the mean of total electricity generation in Malaysia decreases since β_1 is a negative sign by 0.25977 ktoe for export of crude oil when the other four independent variables do not change. Each of the coefficients has a positive sign which means we can estimate the mean of total production in Malaysia raise by the predicted coefficients when the other variables remain unchanged. For β_2, the total production will increase by 0.244212 ktoe of petroleum to be exported while the rest of the independent variables will be constant.

Same goes to other variables as well. The total electricity generated rises by 0.14185 ktoe from imported coal when others keep unchanged. For variable β_4, import of crude oil, it contributes to 0.22373 ktoe increases to the total generation of electricity. Lastly, increasing 0.55106 ktoe of import of petroleum leads to an increase in the production of electricity as well and at the same time, the other independent variables are constant.

R^2

Apart from that, multiple coefficients of determination which is denoted R^2 is one of the important elements that must be considered in doing regression analysis. Definition of R^2 is the proportion of the total variation in the total number of observed values of the dependent variable that is described by the overall regression model. The R^2 defines the strength of the model's relationship with the response variable. Based on the result obtained from **Table 2**, R^2 is 0.9702 declares that the total electricity generation in Malaysia model with five independent variables explains 97% of the total variation in the thirty-eight estimated total production of electricity. Based on this result, we may conclude that the proposed regression model explained the suggested factors well.

F-Test

The F-statistic for the model is 208.3 based on 5 independent variables and 32 degrees of freedom. Since F-statistics (model) = 208.3 is more than $F_{[0.05]}$ = 2.5336, we reject the H_0 in favour of H_1 at 0.05 level of significance. This gives us a piece of strong evidence to conclude that the total electricity generation in Malaysia model is significant. Since the p-value of F-test is significant, the regression model predicts the response variable better than the mean of the response.

Fitted Curve

Curve fitting is required to see the differences between the fitted values and the observed values. Based on **Fig 2**, the blue line represents electricity production while the red line represents the fitted data after undertaking a regression analysis. We can see the pattern of the graphs. Roughly, in 1982, it has been predicted that the total electricity generation in Malaysia is increasing significantly but the real data show us a slight increase than in previous years. In 2009, the result shows conversely, whereby the values are increasing over the years. To estimate the trend in future, it can be one of the guidelines in preparing the strategy to maintain the energy supplies sufficiently.

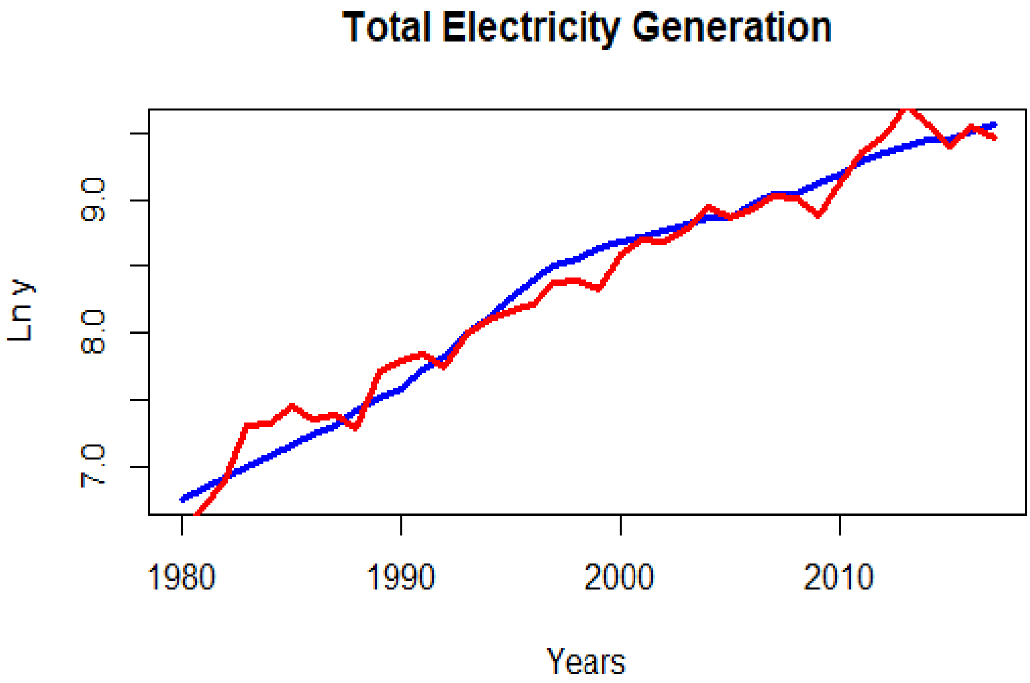

Fig 2. Total Electricity Generation in Malaysia from 1980 to 2017 Against Fitted Data

IV. RESIDUAL ANALYSIS

Residual analysis is vital to check the validity of the regression assumptions. **Fig 3** displays the scatterplot of the residuals. The seasonality pattern is observed in the residuals plot. We show a quantile-quantile plot in **Fig 3** to show the correlation between the sample and the normal distribution. There is an orange line which is called a 45° reference line. All the residuals must be in a straight line and followed the 45° reference line. Based on **Fig 4**, most of the residual points fall nearly on the reference line. In general, we can conclude that the residuals follow the normal distribution.

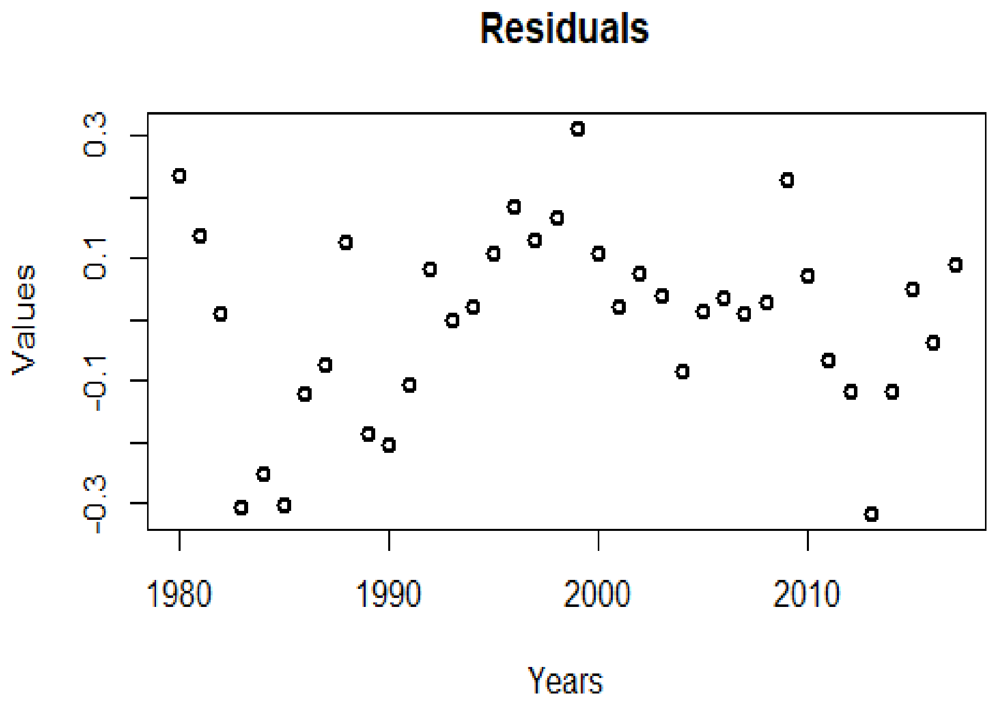

Fig 3. Scatterplot of Residuals

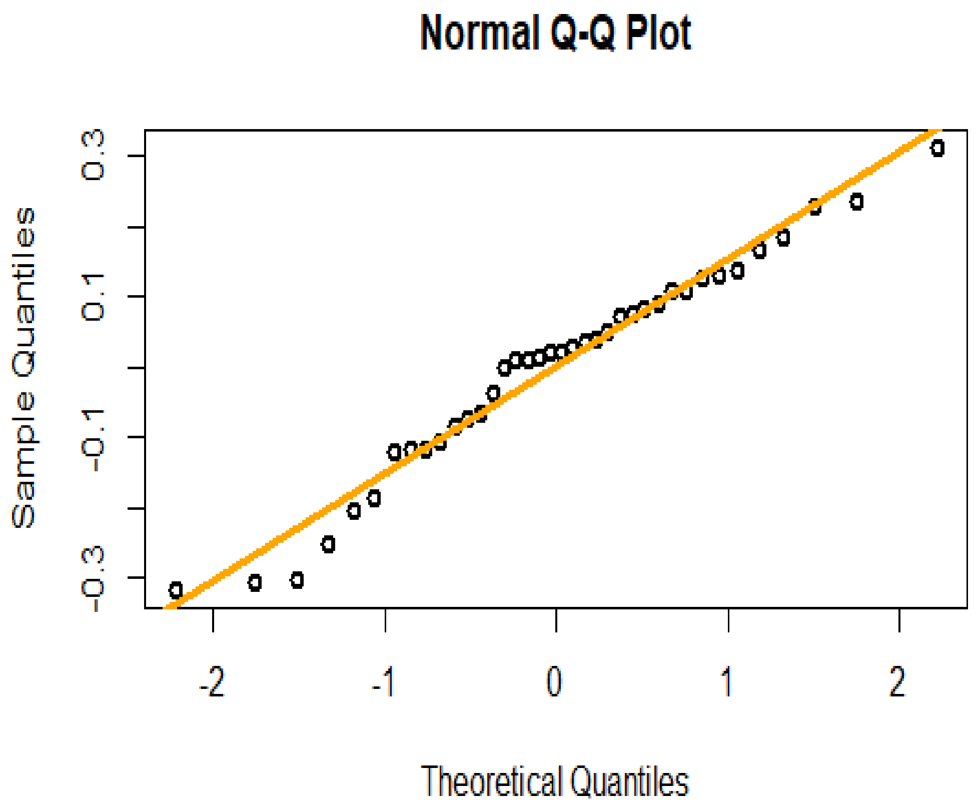

Fig 4. Normal Residuals Plot

KS Test
Kolmogorov-Smirnov (KS) test is used to quantify the difference between cumulative distributions of the data sets, which often used to check the normality of the data. The null hypothesis, H_0 for the test is the residuals have a normal distribution while alternative hypothesis, H_1 is the residuals are not normally distributed. We do not reject the H_0 if the p-value of the KS test is more than $\alpha = 0.05$whereas accept the H_1 if the p-value is less than $\alpha = 0.05$ at 0.05 significance level. The p-value of the KS test is found to be 0.5159. Thus, we have strong evidence to not reject the null hypothesis at the 0.05 significance level. We may conclude that the residuals are normally distributed.
Test of Significance
Based on the result reported in Table 2, all variables are found to be statistically significant in total electricity generation in Malaysia except for the export of crude oil. Based on the result, we can conclude that we have strong evidence to say that export of petroleum (x_2), import of coal (x_3), import of crude oil (x_4) and import of petroleum (x_5) are significantly related to the total generation of electricity in Malaysia (y_t). All of these variables are important and statistically significant to be included in the model. Conversely, we do not have enough evidence to prove the significance of the export of crude oil (x_1). The p-value of this variable is 0.2168 which is much higher than our significance level, $\alpha = 0.05$.

Pearson Correlation

Table 3. Pearson Correlation

Variables	Correlation between Variables					
	y	x_1	x_2	x_3	x_4	x_5
y	1.0000	-0.1810	0.8672	0.9640	0.7108	0.9184
x_1	-0.1810	1.0000	0.2211	-0.0906	-0.5578	-0.1424
x_2	0.8672	0.2211	1.0000	0.8811	0.3976	0.8177
x_3	0.9640	-0.0906	0.8811	1.0000	0.6674	0.9017
x_4	0.7108	-0.5578	0.3976	0.6674	1.0000	0.5213
x_5	0.9184	-0.1424	0.8177	0.9017	0.5213	1.0000

Table 3 presents the Pearson correlations to measure the correlation of two variables. The result shows that the export of crude oil, $x_1$is negatively correlated with total electricity generation in Malaysia while the export of petroleum, x_2, the import of coal,x_3, import of crude oil, $x_4$and the import of petroleum, x_5, are positively correlated with the total electricity generation. It can be seen clearly in **Table 3** that the Pearson correlation between the export of crude oil and the total production of electricity is -0.1810, revealing a weak relationship. In general, we may conclude that all of the variables are correlated with each other. Coal, crude oil and petroleum are the main sources for electricity generation. All variables except the export of crude oil have a significant positive relationship to the total electricity generation. The highest correlation between the independent variables is between the import of petroleum (x_5) and import of coal (x_3). On the contrary, the import of crude oil (x_4) shows the lowest negative relationship with the export of crude oil (x_1).

Limitation
Lack of data is one of the reasons for the non-stationarity of the actual data. Based on the ADF test, all variables used are found to be stationary and do not have a unit root at first difference. We use the annual data and we believe the result will improve if we have large data available such as monthly or quarterly. Secondly, as widely known, Malaysia is highly using coal as our energy source to generate electricity. But since we lack data, we exclude it in our study. Thirdly, the fitted curve does not give a smooth line. For any curve fitting, it should have a smooth fit curve. This is most probably due to insufficient data. The data should be more than 30 data to get an accurate and better result.

V.CONCLUSIONS

Currently, our main energy sources to generate electricity in Malaysia are non-renewable energy. Coal, crude oil, and petroleum are the important energy supplies where its quantity should be sufficient to fulfil the high electricity demand. Hence, importing and exporting the sources are essential to make sure the availability of the energy sources inadequate amount for production. Using OLS and correlation methods, our results show the positive impact of export of petroleum, import of coal, import of crude oil and import of petroleum to the electricity generation in Malaysia exclude for export of crude oil. The export of crude oil seems to give an adverse effect on total production. Our study proves that the import of petroleum is highly influenced by the total generation of electricity since 1980. Lastly, all of the independent variables are correlated with each other. For future research, we recommend expanding the model by introducing additional independent variables. For instance, one may include the export and import of natural gas and coal. Due to the lack of the availability of the data, we do not include these two variables in the model to be studied. Lastly, we also recommend using more frequent time range such as monthly or quarterly data to get a more accurate result and observe the pattern of seasonality in the total production of electricity in Malaysia.

Data Availability

No data was used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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Competing Interests

There are no competing interests.

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